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INTERFACE MESSAGE PROCESSORS FOR
THE ARPA COMPUTER NETWORK

QUARTERLY TECHNICAL REPORT NO. 11
1 July 1971 to 30 September 1971

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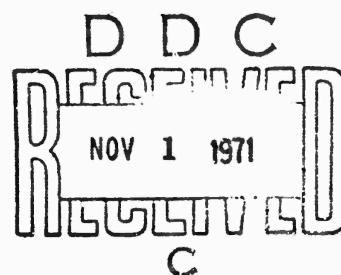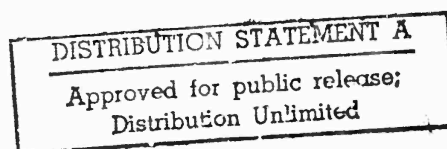Advanced Research Projects Agency
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13. ABSTRACT

The basic function of the ARPA computer network is to allow large existing computers (Hosts), with different system configurations, to communicate with each other. Each Host is connected to an Interface Message Processor (IMP), which transmits messages from its Host(s) to other Hosts and accepts messages for its Host(s) from other Hosts. There is frequently no direct communication circuit between two Hosts that wish to communicate; in these cases intermediate IMPs act as message switchers. The message switching is performed as a store and forward operation. The IMPs regularly exchange information which: allows each IMP to adapt its message routing to the conditions of its local section of the network; reports network performance and malfunctions to a Network Control Center; permits message tracing so that network operation can be studied comprehensively; allows network reconfiguration without reprogramming each IMP. The Terminal IMP (TIP), which consists of an IMP and a Multi-Line Controller (MLC), extends the network concepts by permitting the direct attachment (without an intervening Host) of up to 64 dissimilar terminal devices to the network. The Terminal IMP program provides many aspects of the Host protocols in order to allow effective communication between a terminal user and a Host process.

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	ROLE	WT	ROLE	WT	ROLE	WT
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Store and forward communication						
ARPA Computer Network						
Interface Message Processor						
IMP						
Terminal IMP						
TIP						
Honeywell DDP-516						
Honeywell DDP-316						
Multi-Line Controller						
MLC						
Network Control Center						
Host Protocol						

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Submitted to:

Advanced Research Projects Agency
Arlington, Virginia   22209
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1. OVERVIEW

This Quarterly Technical Report, Number 11, describes
aspects of our work on the ARPA Computer Network during the third
quarter of 1971.

Our efforts during this quarter were again primarily devoted
to the Terminal IMP. The first two TIP field installations were
made during the quarter, the TIP program was refined, additional
terminals tested, and a preliminary TIP User's Guide was pub-
lished. Section 2 describes Terminal IMP developments in greater
detail.

Major changes were made to the Network Control Center com-
puter program during the quarter, particularly in the mechanisms
available for reporting Host traffic. Traffic is now separated
into the eight categories defined by each possible combination of
three parameters:

- input or output
- internode or intranode traffic
- packets or messages

These traffic statistics, as well as other data provided by the
NCC program, are currently printed on a Teletype connected to the
NCC computer, and any desired data reduction is performed by hand.
Some consideration has been given to methods of storing the data
in machine-readable form but there are, as yet, no firm imple-
mentation plans.

A significant effort was made during the past quarter to
revise existing IMP system reports and to generate new reports
required for the Terminal IMPs. Most of these documents are

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expected to be completed and distributed by the middle of the
fourth quarter of 1971. They include

- BBN Report No. 1822, *Specifications for the Inter-
  connection of a Host and an IMP;* one minor revision
  distributed and a major revision in progress.
- BBN Report No. 1877, *IMP Operating Manual;* a major
  revision in progress.
- BBN Report No. 2161, *A Study of the ARPA Network
  Design and Performance;* already distributed.
- Terminal IMP Users' Guide; a preliminary version
  has already been distributed as BBN Report No. 2183,
  revisions will be made as we receive feedback on
  desirable program changes from TIP users.
- A hardware maintenance and test manual for the BBN
  Multi-Line Controller; in progress.
- A manual providing specifications for connection of
  terminals to the Terminal IMP's Multi-Line Controller;
  in progress.

Late in the third quarter we began to provide a biweekly
report on Host status to the network community. Status informa-
tion is obtained from a daily "login" survey made from the proto-
type TIP at BBN. This status reporting is provided partially in
response to requests from the Network Working Group, and partially
as a spur to the Host organizations to improve their network
availability. (During the single two-week period in the third
quarter for which data was obtained, only five Hosts responded
to "login" attempts more than 50% of the time; further, the usual
response of one of these Hosts was to refuse the login.)

As documented in BBN Report No. 1822 and elsewhere, the
hardware interface between a Host and an IMP is subdivided into
two separate units, a *standard* interface which is provided with
the IMP and a *special* interface which is normally provided by
the Host organization. However, due to some unusual circumstances
involved in the experimental use of the network by two US Air
Force sites, BBN agreed to design and fabricate the special Host
interface required for each of these sites. The design was per-
formed during the past quarter.

The intended Host computer at each of the two sites is a
Univac 418 III; thus only one interface design was required.
Early in the design study we decided (based on our interfacing
experience and on some knowledge of the experiments planned)
that the special interface should provide full-duplex communica-
tion. We then undertook a careful investigation of the possible
methods of connecting the interface to the Univac hardware; this
investigation, which involved both study of available 418 III
documentation and discussions with Univac engineers, disclosed
two alternatives:

1) Connection to a standard Communication Terminal Module
    Control (CTMC) via a Univac (custom designed) Communica-
    tion Terminal Module (CTM). This method would allow
    data to be passed over two nine-bit half-duplex connec-
    tions.

2) Connection directly to the Input-Output Module (IOM)
    which is an 18-bit parallel full-duplex I/O channel.

Because of stringent restrictions on the ability to pass
"status" and control information inherent in the CTMC design,
compared with the simplicity and flexibility of the IOM, the
latter approach was chosen.

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Design of the special interface is based on standard TTL
logic. Diagnostic features include status lights, the ability
to loop the IMP side, and provisions for simulating both the IMP
and the IOM sides. Both interfaces were well into the fabrication
phase by the end of the quarter.

2. TERMINAL IMP

During this quarter the first two Terminal IMPs were de-
livered and installed at NASA/AMES and at MITRE. The first of
these was installed on schedule early in August. The second
installation was delayed due to severe damage to the Terminal IMP
during shipping from BBN to MITRE. Damaged components were re-
placed in the field and the machine was in use about one week be-
hind schedule. Once the machines were in actual operation some
bugs were uncovered; these were corrected, and several additions
and improvements were made, by two updates to the terminal-
handling program. By the end of the quarter Version 3 of the TIP
program was in field use.

In addition to the two TIP field installations, the prototype
Terminal IMP at BBN is frequently incorporated into the network.
The prototype TIP is used both for checkout of new terminal types
and for test interaction with the network at large. For example,
our bi-weekly report to the Network Working Group on Host status
is based primarily on information gathered via the prototype TIP.

Version 3 of the TIP program has been operated with seven
different terminals and with the type 103A modem in the BBN test
cell. In addition, users have reported successful operation with
four other terminals. The terminals tested are:

- Model 33 Teletype (ASCII code) - tested at BBN.
- Model 37 Teletype (ASCII code) - tested at BBN.
- Infoton Vista 1-H Alphanumeric CRT (ASCII code) - tested
  at BBN at speeds of 110, 150, 300, 600, 1200, 1800, and
  2400 bits per second.

- IMLAC PDS-1 Graphics Terminal used as an alphanumeric
  display (ASCII code) - tested at BBN at speeds of 110,
  1200, and 1800 bits per second.
- Execuport (ASCII code) - tested at BBN at speeds of
  110, 150, and 300 bits per second. This terminal differs
  from the   er ASCII terminals in that delays must be
  introduced into the computer-to-terminal data stream
  following carriage-return.
- IBM 2741 Terminal (PTTC code) - tested at BBN. There
  are at least six possible keyboard code (and matching
  type element) versions of this terminal. We have tested
  one version and provided code conversions for three other
  versions.
- IBM 2741 Terminal (Correspondence code) - tested at BBN.
  There are at least four possible keyboard code versions
  of this terminal. We have tested one version and pro-
  vided code conversions for three other versions.
- Hazeltine alphanumeric CRT - tested by a user.
- Telterm 2 - tested by a user.
- Tectran cassette - tested by a user.
- Datapoint 3300 alphanumeric CRT - tested by a user.

In addition to these terminals, we continued program develop-
ment necessary to interface the ODEC Line Printer (which requires
timed delay after paper advance commands), the type 202C modem,
and the Honeywell magnetic tape controller and drive. We have
also conducted a preliminary survey of "remote batch" terminals,
but have not, as yet, been able to resolve the technical diffi-
culties which prevent effective use of these devices with the
Terminal IMP.

Unlike the other IMP software, the TIP program interacts both with human terminal users and with portions of the Host protocol. Thus we have always expected at least three sources of pressure for changes in the TIP program.

1) User requests for the connection of new terminal types, which may have requirements for new code conversions, special timing after certain characters (e.g., carriage-return or line-feed), or special "control" routines (e.g., 202C modem or magnetic tape).

2) Changes or additions to the Host protocols defined by the Network Working Group (e.g., definition of a remote job service protocol).

3) User dissatisfaction with the TIP "control language" which provides the interface between the terminal user and the network (e.g., desire for "better" abbreviations for commonly used commands).

Subsequent to the installation of the first TIP (about half-way through the third quarter) some changes were made to the field version of the TIP program in response to pressures in each of these categories, and work was started on other changes which are not yet ready for release. We expect that this tailoring of the basic TIP program will continue for some time, as users gain more experience in using the network via a TIP terminal and as the Network Working Group gains more experience with the protocols it is developing.